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PRELIMINARY RESULTS ON THE INHIBITION OF PYRITE OXIDATION BY ROAD SALT AND CLAY CAPPING OF HALIFAX PYRITIC SHALES

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PRELIMINARY RESULTS ON THE INHIBITION OF PYRITE OXIDATION BY ROAD SALT AND CLAY CAPPING OF HALIFAX PYRITIC SHALES

by

R.G.L. McCready and J. Salley

ABSTRACT

The Department of Transport plans to cap their pyritic shale waste pile at the Halifax Airport with two feet of clay, six inches of top-soil and revegetate to reduce the acidic drainage. Previous studies have indicated that Thiobacilli are sensitive to low concentrations of sodium chloride. This study reports the preliminary results of a laboratory investigation to assess the effect of a salt-clay capping procedure.

ABSTRAIT

Le département du Transport planifie de recouvrir leur accumulation de schistes usé de pyritique, provenant de l'aéroport d'Halifax, avec deux pieds d'argile, six pouces de terre et de semer afin de réduire l'acidité du sol. Des études antérieures indiquent que le Thiobacilli est sensible à une faible concentration de chloride de sodium. Cette étude rapporte des résultats préliminaires, d'une recherche de laboratoire qui estime l'effet du sel, contenu dans l'argile, comme produit de recouvrement.

INTRODUCTION

Due to construction of new facilities at the Halifax International airport excess pyritic shale and overburden have been stockpiled on the property. On exposure to the atmosphere and precipitation the pyritic components of the shale have undergone oxidation resulting in acid generation and leaching of metals from this waste material.

During studies on the reclamation of solonetzic soils, it was observed that Thiobacilli were unable to sustain viable populations in soils containing 4.8 meq of Na^+/100 g of soil. (McCready 1982; McCready and Krouse, 1982).

Later studies on the adaptation of Thiobacilli to growth in saline waters indicated that T. ferrooxidans could not tolerate sodium chloride concentrations greater than 1% w/v (McCready, unpublished).

It was therefore postulated that the incorporation of a salt layer between the pyritic shale waste and the overlaying clay cap would add an additional bacteriostatic activity to the oxygen depletion effect of the clay capping.

A laboratory study was conducted to test this hypothesis.

MATERIALS AND METHODS

Four columns (6 cm dia x 50 cm length) were loaded with one kg of Halifax shale and overburden which was supplied by the Department of Transport as shown in Figure 1.

Two of the four columns had 5 grams of road salt placed on the surface of the shale. One salt supplemented column and one unsupplemented shale column were inoculated with 500 mL of a 96 hour culture T. ferrooxidans grown on the low phosphate medium (McCready et al., 1986). The other salt-supplemented column and the remaining unsupplemented column were trickle leached with distilled water. The distilled water and the T. ferrooxidans cultures were circulated through the columns using a Gilson Minipuls-2 peristalic pump set at a flow rate of 300 mL/h.

Samples of the recirculating solutions were collected periodically from the four columns for pH determinations and ferric iron analyses. The total

volume of solution for each column was kept constant at 500 mL by the periodic addition of distilled water.

To assess the effect of a salt and clay cap two additional columns were prepared as shown in Figure 2. The test column had a layer of road salt placed between the pyritic shale sample and the clay layer which was tightly compacted in both columns. Two hundred and fifty mL of distilled water was added to each column to assess the percolation rate through the clay.

RESULTS AND DISCUSSION

Effect of Road Salt on Ferric Iron Production

When the cultures of T. ferrooxidans were recirculated through the pyritic shale columns the soluble ferric iron content of the solution decreased due to adsorption of the iron to the clays in the shale/overburden mixture. After 1 month, the soluble ferric iron concentration of the leachate increased in the nontreated column due to microbial activity (Fig. 3). This was confirmed by microscopic examination of the leachate; after 50 days the leachate contained about 10^6 organisms/mL.

In contrast, in the salt treated columns, the soluble ferric iron content decreased over the first 20 days and remained at a minimal concentration until the experiment was terminated. No active bacterial cells were observed during microscopic examination of the leachate.

In the two columns leached with distilled water there was very little iron release and no T. ferrooxidans could be detected in the leachate. Extensive physical breakdown of the clay components of the overburden were observed in the salt supplemented column. The continuous recycle of the saline solution most likely resulted in the stripping of calcium ions from the clays and the sodium ion replaced the calcium in the binding sites. This resulted in the formation of clay fines which plugged the column after 35 days. Repeated back flushing of the column finally resulted in clearing of the silt and the experiment was continued to the 58th day.

Effect of a Salt and Clay Capping

After compacting the clay and soil layers on the two columns, 250 mL of distilled water was placed on the top of the columns. None of this water

penetrated through the clay layers in either column. After two weeks the added water had evaporated and the soil and clay layers were allowed to dry out.

The clay layer in the column without salt cracked vertically and on rewetting with 250 mL of water, the water penetrated through the clay layer and the column within 4 hours, and the clay seal has not resealed to date.

In contrast, the clay and salt seal cracked horizontally on drying. When 250 mL of water was reintroduced it took 12 hours for the water to penetrate through the clay and pyritic shale. On addition of a second 250 mL aliquot of water, the clay re-sealed itself and no additional water percolation through the column has been observed to date.

The water which passed through these two columns was analyzed for iron content and pH. These values are presented in Table 1.

Table 1. pH and ferric iron concentration of the initial effluent and after 250 mL of effluent had passed through the clay sealed columns.

		pH	Fe^{+3} ppm
Clay alone	First 5 mL	2.47	292
	After 250 mL	2.60	82
Clay + NaCl	First 5 mL	2.41	98
	After 250 mL	2.51	34

CONCLUSIONS

The addition of a salt layer between the pyritic shale and the clay cap resulted in: (1) a higher water retention time by the clay cap as indicated by the longer time required for drying and cracking of the clay layer.

(2) On drying, the clay cap cracked horizontally, rather than vertically, thereby preventing oxygen penetration to the underlaying shale.

(3) On re-wetting, the salt induced swelling of the clay results in the reformation of an impermeable seal more quickly than in the absence of salt.

In addition, if the clay cap is ruptured, any water percolation would result in the leaching of soluble salt into the shale thereby inhibiting any thiobacilli within the water penetrated shale.

There preliminary results, indicate that the application of a salt layer between the pyritic shale and the overlaying clay cap should be beneficial in maintaining the cap integrity and simultaneously provide a bacteriostatic effect within the pyritic shale.

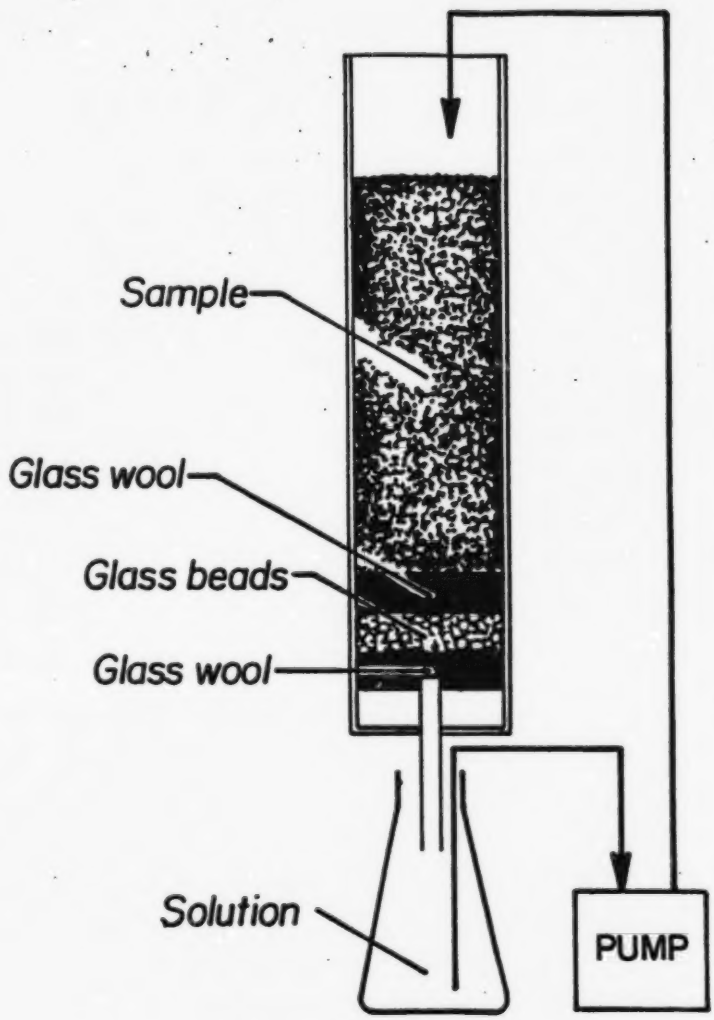

Figure 1 Column design for testing the effect of 1.5% w/v NaCl

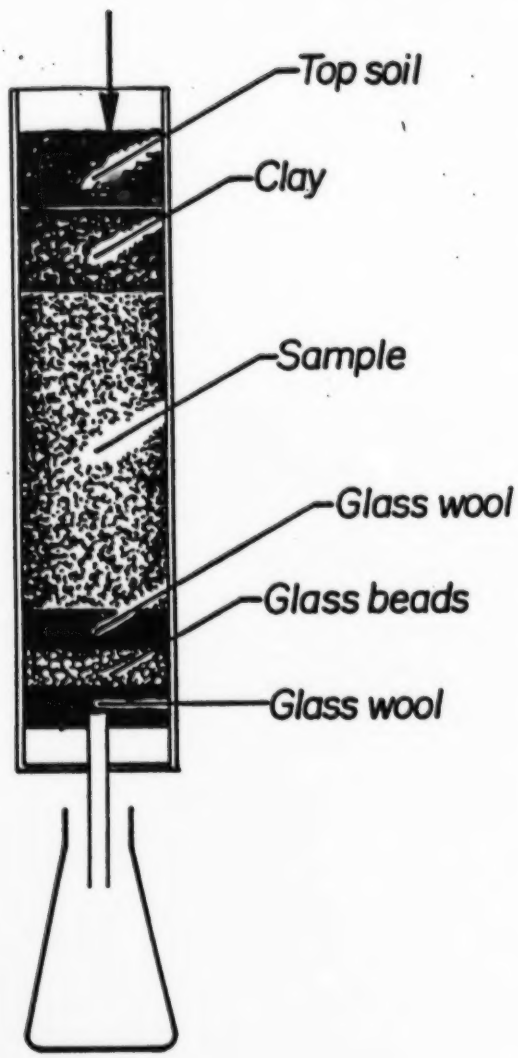

Fig. 2 Column design for testing a band of NaCl between the shale and clay layers

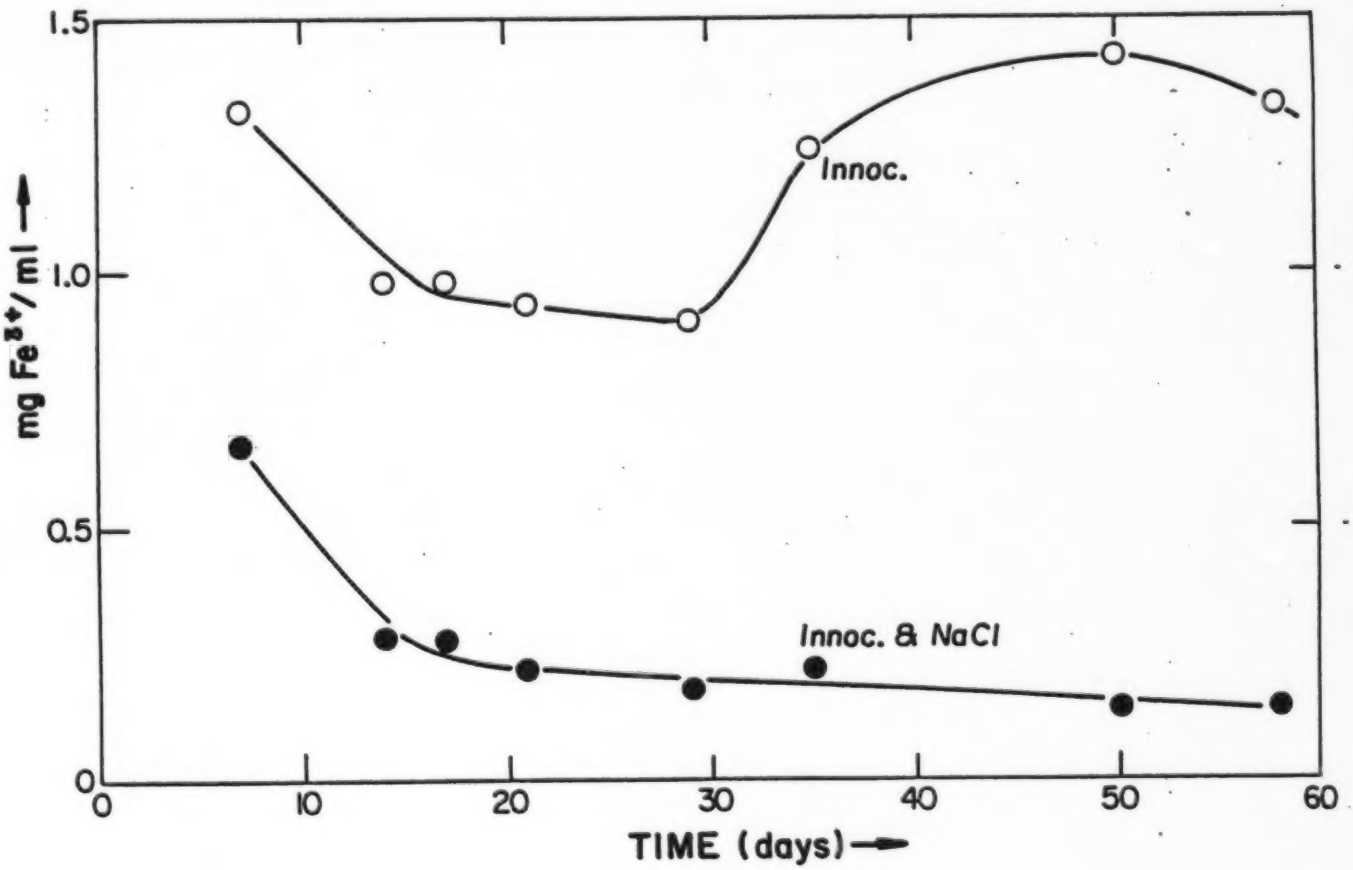

Fig. 3 Fe^{+3} content of the leachate with innoculated shale in the presence and absence of NaCl

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